



**Arizona
Department of Transportation**

WORKBOOK

for

**FIELD SAMPLING
AND TESTING FOR
CONCRETE CONSTRUCTION
(Course Number 201)**

a training course developed
for the

ARIZONA DEPARTMENT OF TRANSPORTATION
Phoenix, Arizona

by

ROY JORGENSEN ASSOCIATES, INC.
Gaithersburg, Maryland

Revised by ADOT – October 20, 2006

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Directions to Workbook Users

Field Sampling and Testing for Concrete Construction (Course Number 201) is one in a series of courses on inspection and quality control for concrete construction. Other courses in the series include:

- Incidental Concrete Structures Inspection (Course 202),
- Concrete Paving Inspection (Course 203), and
- Major Concrete Structures Inspection (Course 204).

This course is designed primarily for highway construction inspection personnel, but it can also be used in training other personnel.

This workbook is to be used in conjunction with a videotape presentation, discussion sessions with the trainee's instructor or supervisor, and other materials that make up the course. As sections of this Workbook are assigned, each trainee should:

1. read and study the material to review previously presented information and gain additional details;
2. complete the exercises and quizzes as they are provided;
3. check his answers against those provided following the exercise or quiz;
4. review the material as needed to correct and clarify any incorrect answers; and
5. discuss any areas that are still not clearly understood with his instructor or supervisor.

Each trainee should be provided with his own copy of this Workbook so that he can write in it and keep it for future reference and review.

This course is based primarily on the established sampling and testing methods detailed in:

- ADOT's *Materials Testing Manual*,
- ADOT's *Materials Policies and Procedures Directives*,
- ADOT's *Standard Specifications*, and
- American Association of State Highway and Transportation Officials (AASHTO) and American Concrete Institute (ACI) Materials Tests.

The appropriate source document and section is identified for each method covered in this Workbook.

Notes

First Discussion Period
(Introduction and Sampling Related Materials)

Section One: Concrete

Concrete has a wide variety of uses in road construction, including:

- incidental structures, such as catch basins, curb and gutter, sidewalks, barrier walls, retaining walls, slope pavement, and box culverts;
- concrete pavement; and
- major structures, such as various types of bridges.

The inspection of each of these uses of concrete are covered in other courses in this series. This course concentrates on the sampling and testing responsibilities of field personnel who inspect concrete construction.

Materials for Concrete Construction

The different types of materials used in concrete construction generally can be categorized into two basic groups:

1. component materials that are used in producing the concrete, and
2. related materials that are used in conjunction with the concrete at the construction site.

Concrete consists primarily of four basic types of component materials:

1. aggregates, as the basic “building blocks” of the concrete;
2. hydraulic cement, which reacts with water to form a paste that hardens into a rigid binder;
3. water, to react with the cement; and
4. admixtures, such as air-entraining agents, water-reducers, plasticizers, accelerators, retarders and fly ash.

A variety of other related materials are used in conjunction with concrete at the construction site, including such items as:

- reinforcing steel,
- structural metals,
- curing compound,
- joint materials, and
- metal and plastic ducts.

Key Characteristics of Concrete

The effectiveness of any concrete depends largely on its characteristics before, during, and after it hardens.

The key characteristics of fresh concrete include its:

- **consistency** – its plasticity or ability to hold its shape, usually measured as its “slump”;
- **uniformity** – the even distribution of the component materials within the mix;
- **workability** – the ease with which it can be handled and finished with a minimum of segregation of the component materials;
- **air content** – the percentage of air in the mix, including:
 - “entrained” air, which consists of small, microscopic air bubbles that are intentionally in the mix for improved workability, and
 - “entrapped” air, which includes larger, irregular voids that are undesirable and should be mostly removed by consolidation; and
- **temperature of concrete** – too hot or too cold for placement.

Several key terms that help define the process that concrete goes through as it hardens, include:

- **hydration** – the overall chemical reaction between the cement and water that eventually produces a hard, rigid compound;
- **set** – the initial stiffening of the concrete to the extent that it can resist penetration and support itself before it is fully hardened; and
- **curing** – any of several different methods used to slow the hydration process in order to control such factors as shrinkage and cracking.

The key characteristics of hardened concrete are its:

- **strength** – its ability to bear a load without breaking, including:
 - “compressive” strength to resist breaking under a crushing force, and
 - “flexural or tensile” strength to resist breaking under a bending force; and
- **durability** – its ability to resist deterioration from weathering, chemical reactions and abrasion.
- **deformation resistance** – its ability to resist deformation due to shrinkage, elastic loading, and creep.

Classes of Concrete

There are three basic classes of concrete:

- **Class “B” concrete**, which is generally used for relatively minor or incidental structures which must bear little or no load other than their own weight;
- **Class “P” concrete**, which is specifically designed for concrete pavement which must bear the direct loads of traffic; and
- **Class “S” concrete**, which is used primarily for major structures which must bear the heavy loads of other structural elements and embankments as well as traffic.

Responsibilities for Sampling and Testing (Section 1006-7)

The contractor, materials labs, and field inspectors all have certain responsibilities for sampling and testing materials used in concrete construction.

The contractor has an overall responsibility for controlling the quality of all materials used. More specifically, he must:

- certify that the materials meet their specified requirements, and
- provide representative samples for testing.

The Department’s materials labs are generally responsible for conducting certain tests which cannot be performed effectively at the construction site. These include tests for:

- component materials such as aggregates, hydraulic cement, admixtures, and water;
- related materials, such as reinforcement, joint materials, and curing compound; and
- concrete compressive-strength cylinders and flexural-strength beams.

The field inspector at a concrete construction site is responsible for:

- checking the mix design and obtaining representative samples of such related materials as:
 - reinforcing steel,
 - joint materials, and
 - curing compound;
- sampling fresh concrete;
 - preparing concrete cylinders for compressive-strength testing and beams for flexural-strength testing;
- testing fresh concrete for:
 - slump,
 - air content, and
 - temperature.

Documenting Concrete Testing

The results from all testing are documented using the Concrete Report in the Pen Inspection Forms software.

Notice that the key information to be documented at the construction site includes:

- identification of the project;
- ticket number, quantity and truck number of the load from which the sample was collected;
- batch and sample time and date (and information on any additional water added or mixing done at the site);
- identification of the station and part of the structure or pavement represented;
- temperatures of the concrete and ambient air at the time of testing;
- slump test results;
- air content test results; and
- numbers of the cylinders or beams prepared.

The curing times, specimen dimensions, test loads and stresses for the strength specimens are recorded at the lab and sent back to the project. If you make a mistake, document it and start over.

Section One Quiz

1. Which of the following types of materials are “component” materials used in the production of concrete mix? (Circle one or more)
 - a. curing compound
 - b. air-entraining agent
 - c. hydraulic cement
 - d. reinforcing bars
 - e. neoprene joint seal
 - f. water
2. Which types of materials are “related” materials used at the construction site in conjunction with concrete? (Circle one or more)
 - a. curing compound
 - b. air-entraining agent
 - c. hydraulic cement
 - d. reinforcing bars
 - e. neoprene joint seal
 - f. aggregates
3. Which class or classes of concrete would be used in a concrete bridge abutment? (Circle one)
 - a. Class P
 - b. Class B
 - c. Class S
 - d. Any of the above classes
 - e. None of the above classes
4. Which of the following is a characteristic of fresh concrete mix that is usually measured by its “slump”? (Circle one)
 - a. workability
 - b. durability
 - c. consistency
 - d. hydration
 - e. strength
5. Which of the following materials are both sampled and tested at the field construction site by the inspector? (Circle one or more)
 - a. aggregates
 - b. fresh concrete mix
 - c. curing compound
 - d. reinforcing steel
 - e. hydraulic cement

Section One Quiz Answers

1. b. air-entraining agent
c. hydraulic cement
f. water
2. a. curing compound
d. reinforcing bars
e. neoprene joint seal
3. c. Class S
4. c. consistency
5. b. fresh concrete mix

Section Two: Certification and Sampling of Related Materials

Concrete construction involves a variety of related materials such as reinforcing steel, structural metals, joint materials, and curing compound. These materials must be controlled by certification, sampling or both.

Materials Certification (Std. Spec. 106.05)

For most of these related materials, the contractor must provide certification that the materials meet the specified requirements.

Certification of Compliance

Most related materials require a Certificate of Compliance which must include the:

- prime coat – per CB 89-17,
- project number,
- name of the contractor,
- type of material,
- quantity of material represented,
- number or other names of identifying the lot or batch,
- identification of the appropriate specifications for the material,
- statement that the material complies with all requirements of the appropriate specifications for the material, and
- the original signature of the contractor's or supplier's authorized representative (Officer of Company).

An example of a Certificate of Compliance is shown in the 1000 series of the ADOT *Materials Testing Manual*.

Certificate of Analysis

A Certificate of Analysis is required for some materials. It includes:

- all information required in a Certificate of Compliance, and
- the results of all tests required by the specifications.

Other Certifications

For certain materials, additional information or markings may be required to certify that the Department has pre-tested and approved the material. Depending on the type of material, this certification may take the form of:

- a laboratory test number included in the Certificate of Compliance,
- a green tag on the material, or
- a stamp on the material.

When any of these pre-testing indications are used, you must still contact the lab for verification of the approval.

Sampling Related Materials

Certain types of related materials, which are defined below, must also be sampled at the construction site.

Reinforcing Steel (Std. Spec. 1003 and Materials PPD's)

A Certificate of Compliance is required for all reinforcing steel, including reinforcing bars, welded wire mesh and wire or cable.

For reinforcing bars:

- if the Certificate includes an ADOT lab number or if the bars include an ADOT lab number:
 - contact the Central lab to verify the lab number,
 - collect a 6-foot sample from the shipment as a spot-sample; and
 - do not accept test bars;
- if there is no ADOT lab number:
 - collect one 6-foot sample at random from each bar size, grade, heat number, and manufacturer, and
 - await test results before acceptance; and
- be sure that all samples are cut from randomly selected bars (never accept a special pre-cut “test bar” from the contractor as the sample):
 - out-of-state steel;
 - sample every size bar – each lot (PP&D 92-2).

For welded wire mesh:

- no sample is needed if the material has an ADOT green tag; but
- if there is no green tag, cut one 2-foot-by-2-foot sample for every 25 rolls of material and await test results.

For steel wire or cable to be used in pre-stressed concrete, cut two 6-foot samples from each reel and await results.

Structural Metals (Std. Spec. 603, 604 and 1004)

For most structural steel, no sampling is needed at the project site, but:

- a Certificate of Analysis (including the mill analysis test results) is required for such major structural steel as H-piles and girders; and
- the approved heat number must be stamped on the steel itself as a means of identifying its lot.

For high-strength bolts, nuts, and washers, a Certificate of Analysis and:

- sampling of 3 bolts, nuts, and washers, or 0.1% of the lot for lots in excess of 3,000; and
- periodic field testing using a Skidmore-Wilhelm Calibrator, DTI's, or calibration wrench to check bolt tensions during installation.

For bearing pads, a Certificate of Analysis and two pads per 100 or portion thereof with a minimum of one sample pad for each lot for each type of pad are needed for testing. Send samples into the lab 3 weeks prior to use.

Joint Materials (Std. Spec. 1011)

For joint materials:

- a Certificate of Compliance is required for all joint materials;
- five-gallon sample is obtained from each lot of liquid joint material; and
- one 18-inch sample is cut from each lot of solid joint material.

Sealants

The contractor required to have the sealants sampled and approved prior to use. (1011-8.04)

Curing Compound (Std. Spec. 1006 and Materials PPD's)

A Certificate of Compliance is required for all curing compound. If the curing compound is green-tagged or preapproved it can be used without additional sampling if:

- the lot number is verified with the Central Lab,
- the correct project number is shown on the green tag, and
- the container is unopened when delivered to the project.

However, if there is no green tag, collect a sample by:

- seeing that the curing compound is mixed or agitated by either:
 - tilting and rolling the drum for non-pigmented types of compound,
 - or**
 - mechanical agitation for pigmented compounds; and
- collecting one half-gallon for each lot.

Other Related Materials

Pre-cast concrete items require a Certificate of Compliance and an ADOT stamp on the item itself.

Paint is usually pre-tested and green-tagged by the Department and also requires Certification of Compliance. If there is no green tag, collect a one-quart sample for each batch of each type of paint.

The mortar or concrete blocks that are often used as supports and spacers for reinforcing steel must meet the same strength requirements as the structure itself. Rocks cannot be used. Check with the Materials Division for the frequency of sampling these blocks for strength testing.

Sample Identification

All samples must be clearly identified before they are sent to the lab for testing. The sample tabulation card should be fully completed as shown in the example on page 13. Of special importance is the lot or heat number, manufacturer, product type or name, and any identifying product code. The governing specification should also be identified if possible.

PLEASE PRESS FIRMLY
WHILE FILLING OUT FORM

ARIZONA DEPARTMENT OF TRANSPORTATION

44-4301 R1/94

Name of Material _____

Item No. or Specification Section No. _____

Sample No. _____ Lot No. _____ Test Lab. _____

Sampled by _____ Date _____

Sampled from _____
(Hot Plant, Stockpile, Truck No., Sta. No., Etc.)

Quantity Represented _____

Supplier _____
(Original Source, Manufacturer, Refinery, Etc.)

Project No. _____ TRACS No. _____

Project Code _____ ORG No. _____

Project Engineer/Supervisor _____

Remarks: _____

Frequencies For Sampling and Testing

Refer to the ADOT *Materials Testing Manual*, Series 900, pages 29-34 for information on field sampling and testing for concrete mix. For information on certification and sampling for related materials, see Series 1000, page 5, and the *Standard Specifications*, Section 1006.

Section Two Quiz

1. Which of the following statements best describes the basic **difference** between a Certificate of Compliance and a Certificate of Analysis? (Circle one)
 - a. The Certificate of Compliance must be signed and notarized.
 - b. The Certificate of Analysis includes test results as well as the information required for a Certificate of Compliance.
 - c. The Certificate of Compliance is used only for reinforcing and structural steel.
 - d. The Certificate of Analysis indicates that the material has been pre-tested and approved by ADOT's Central Lab and does not need any further sampling and testing.

2. For which of the following materials is a Certificate of Analysis required? (Circle one or more).
 - a. H-piles steel
 - b. neoprene joint seal
 - c. welded wire mesh
 - d. curing compound

3. If the Certificate of Compliance for a shipment of reinforcing bars includes an ADOT lab number, which of the following actions should be taken? (Circle one or more)
 - a. Collect a random 6-foot sample for Central Lab testing.
 - b. Use the special pre-cut test bar as the sample.
 - c. Contact the Central Lab to verify the number.
 - d. Collect an 18-inch sample, but do not hold up use of the shipment until test results are received.

4. In the sampling of curing compound, which of the following statements are applicable? (Circle one or more)
 - a. No sample is needed if a Certificate of Compliance has been submitted.
 - b. See that the curing compound is agitated or mixed before any sample is taken.
 - c. Curing compound is always green-tagged.
 - d. One half-gallon should be collected from each lot whenever a sample is taken.

5. Which of the following indicates that ADOT has pre-tested and approved the material?
(Circle one or more)
- a. a lab number on the Certificate of Compliance
 - b. the mill analysis included as part of a Certificate of Analysis
 - c. a green tag attached to the material
 - d. a heat number stamped on structural steel
 - e. the lot number on any Certificate of Compliance
6. Which of the following related materials is usually **not** sampled at the field construction site? (Circle one or more)
- a. epoxy-coated reinforcing bars
 - b. structural steel
 - c. pre-stressing steel cable
 - d. pre-cast concrete
 - e. welded-wire mesh

Section Two Quiz Answers

1. b. The Certificate of Analysis includes test results as well as the information required for a Certificate of Compliance.
2. a. H-piles steel
3. a. Collect a random 6-foot sample for Central Lab testing.
c. Contact the Central Lab to verify the number.
4. b. See that the curing compound is agitated or mixed before any sample is taken.
d. One half-gallon should be collected from each lot whenever a sample is taken.
5. a. a lab number on the Certificate of Compliance
c. a green tag attached to the material
6. b. structural steel
d. pre-cast concrete

Notes

Second Discussion Period
(Sampling and Testing Concrete)